

**Case Study No. 13 Waterborne, UV-Cured, and Powder Coatings
Knoll
East Greenville, PA**

Background

The Knoll facility located in East Greenville, Pennsylvania, is a part of Knoll, Inc., one of the top manufacturers in the office furniture industry today. Knoll produces a range of products including systems furniture, casegoods, seating, upholstery, fabrics, leather, and office accessories. The East Greenville facility manufactures both metal and wood office furniture. There are approximately 1,300 employees at the East Greenville facility; more than 800 of those are manufacturing employees. The facility also serves as the corporate headquarters for Knoll, Inc.

Knoll is well known within the industry for its commitment to the environment. Knoll made the decision to focus on clean technologies in the early 1980s. Because of this focus, Knoll's East Greenville facility has reduced VOC emissions by more than six-fold since 1983 while simultaneously improving product quality. In 1994, the East Greenville facility was awarded the Governor's Waste Minimization Award, which is given annually by Pennsylvania's Department of Environmental Protection. In 1998, the company was awarded the "Clean Corporate Citizen" award from the State of Michigan.

Knoll management is committed to using clean technology wherever and whenever reasonably possible. Knoll's East Greenville facility is ISO 9000 certified and has started gathering the prerequisite information for becoming ISO 14000 certified. Knoll currently is ISO 9000 certified for health and safety and is working towards the environmental certification being completed by the year 2000.

Knoll's East Greenville facility has reduced emissions in all areas of operation, including finishing, gluing, and cleaning operations. In addition to these significant emission reduction efforts, Knoll has developed a new coating process to apply powder coating on wood components. Full implementation of this process is expected to further reduce facility-wide VOC emissions. The following is a summary of the pollution prevention alternatives employed in Knoll's wood finishing operations.

Wood Finishing Operations

Knoll has switched the majority of its wood finishing operations in East Greenville from solvent-borne coating systems to waterborne and UV-cured coating systems. Knoll has installed a powder coating line to replace much of its waterborne coating usage. The following paragraphs describe each coating system and the facility's experiences while converting from solvent-borne coatings.

Waterborne Coating Line

Approximately 70 percent of the facility's products receive pigmented coatings. Pigmented finishes are applied primarily on particleboard components. Pigmented waterborne coatings are applied using HVLP spray guns. The waterborne coating line is a conveyORIZED hanging line. The line moves at 6.5 feet per minute, and parts take 1 hour and 45 minutes to travel the length of the line. Thirteen to fifteen coating operators work at this line.

The operators apply the coating to the front of each piece, and then turn it around to coat the back. A primer is applied first, and then cured in a conventional oven. A basecoat is applied, which also is cured in a conventional oven. The final coating, used to give the piece a textured appearance, is cured in an IR oven. Knoll expects to replace this line with the powder coating line, with the exception of a few specialty colors.

UV-Cured Coating Line

Knoll installed a UV-cured coating line for applying clearcoats to flat panels in 1995. This line accounts for approximately 30 percent of the production at the facility, primarily finishing veneered products, from 5,000 to 10,000 square feet of panel per day. The finishing line, a Cefla Ecolight™ UV flatline system, can be used to apply up to four coats. The finishing process is relatively automatic. Parts are hand fed onto the conveyor line. The panels are brushed and cleaned before a waterborne washcoat is applied with a roll coater. The panels are dried in an IR oven, then two coats of sealer are applied. The panel is partially cured by UV lamps using a low intensity and short cure time after the first coat of sealer is applied. After the second sealer application, the sealer is completely cured by a set of UV lamps. The panels then are sanded, brushed, and the final topcoat is applied. Final curing is accomplished by the last set of UV lamps, and the panels are allowed to cool. Knoll tracks the amount of coating applied to each piece closely, and operators know how many grams of coating should be applied to a particular panel.

Before moving to a UV-curable coating system at the East Greenville facility, Knoll started using a UV system at its Toronto, Canada, facility. Most of the early parts that were finished with the UV system at the Toronto plant had a closed pore or plastic appearance. Knoll worked extensively with the system at Toronto so that it could achieve the wood grain appearance that they wanted before installing the system in East Greenville. The company spent approximately \$2 million at the Toronto plant and another \$1.5 million on the system at the East Greenville facility. The system is expected to pay for itself within 4 to 5 years.

The facility experienced only minimal downtime in switching to the UV system. The facility hired outside engineers in the planning stages to help facilitate the transition. These engineers were responsible for training the employees before the system was installed so that operation of the line would not be delayed by employee training.

Powder Coating Line

Knoll spent four years and more than \$2 million developing a powder-on-wood technology to use on the MDF components of many of its products. The powder-on-wood process will replace much of the current waterborne technology and further reduce the East Greenville facility's VOC emissions. The powder coating is durable and has excellent color consistency and reproducibility.

Knoll ran hundreds of tests, working with the equipment and coating suppliers, in developing the process. The process that was developed is computerized and the production line requires seven operators. Two operators load parts onto the line, two operators run the line, two operators take parts off the line, and one operator performs material handling duties. The parts are bar coded prior to the coating process. Once the parts are loaded onto the line, they are scanned and the computer responds with the appropriate process adjustments for that part. The system is capable of distinguishing between small and large pieces and can adjust the number of spray guns used to coat the parts and configure the curing ovens accordingly. This minimizes overspray and energy usage for the curing ovens.

The parts pass through the coating booth on a hanging line. In the powder coating process there is no presanding step; the wood operators must carefully inspect the quality of the parts prior to the coating operation. The first two pieces on the line are "dummy" boards that signal the ovens to come online when they pass an electric eye (the ovens run at idle when there are no parts passing through them). The line moves at about 10 feet per minute, and the ovens take about one minute to heat up. The pieces first pass through a preheating oven. They then enter the spray chamber, where a series of guns moves up and down to coat the piece with 3 to 5 mils of powder. There are two arms on each side of the spray chamber that move up and down, with four guns per arm. Electric eyes sense how large the piece is and the appropriate number of guns are used. The pieces then pass through a 60-foot long, gas-fired IR oven and a subsequent cooling chamber. The curing time is approximately one minute. The cooling chamber is 150 feet long and reduces the temperature of the parts down to 95°F. Any pieces with coating defects are sanded and recoated.

A color change in the powder coating process takes approximately 45 minutes to complete. The actual down time for the production coating line is only 5 to 10 minutes and the design of the line minimizes labor time and equipment moving. There are two spray chambers that may be used interchangeably, so when a color change occurs, one is being cleaned while the other is being used. There are dedicated pots and transfer lines for each color; Knoll makes four color changes each operating shift with their current mix of products.

The payback for the investment in the powder-on-wood process is projected to be 2.3 years and will come from saved coating material costs and labor efficiency in operating the line. Full implementation of this new process is expected to increase the facility's capacity.

In developing the powder-on-wood process, Knoll evaluated three different types of spray guns from three different companies. The equipment, even though dedicated to the powder line, could be used on the wet (waterborne) line with only minor modifications if needed. The total line is 550 feet long and considered compact in comparison with most wet coating lines. The powder line typically will run at 10 feet per minute compared to 6.5 feet per minute for the waterborne coating line.

The coating line was designed with continuous flexibility. The line can handle seven different colors and three different board thicknesses, and there are plans to add the capability to coat some plastic components, such as drawer fronts. The line can coat components with dimensions up to 4 feet by 10 feet. Some of the components had to have minor design modifications to accommodate the powder coating process. For example, areas that have been milled out for hinges may be too thin to retain enough heat from the preheating oven for the coating to stick.

The spray chamber is equipped with a cyclone powder recovery system. Knoll estimates that the cyclone recovery system will capture almost all of the powder overspray and the spray guns will have at least 90 percent transfer efficiency (as opposed to an estimate of 40 percent transfer efficiency for the wet coating processes). The powder overspray is directed via airflow into the cyclones, collects at the bottom in the hopper, and is mixed back in with virgin material fed to the spray guns. On very small specialty jobs, the powder overspray will not be reclaimed/recycled, but will be collected as waste.

The powder coatings are shipped from the supplier to Knoll in small bags inside of cardboard boxes and stored in an adjacent room with a controlled environment. The temperature is maintained between 72° and 78°F and between 40 and 50 percent relative humidity. The coating storage room is designed to hold up to 23,000 pounds of coating. The powder coatings cost about \$7.50 per pound compared to the previous waterborne products which ranged from \$25 to \$40 per gallon with 40 to 45 percent solids. From a material cost perspective, the waterborne coatings cost \$0.48 per square foot of surface coated and the powder coatings cost \$0.17 per square foot of surface coated.

The moisture content of the types of components being run on Knoll's powder line is very consistent, usually 6 to 8 percent. Facility personnel commented that they sometimes see problems with boards splitting in the curing oven if the moisture drops down to 3 percent or below. Knoll typically keeps a 10-day supply of components at their facility. Facility personnel noted that the board suppliers do a good job of rotating their stock and consistency problems involving moisture content are rare. The core temperature and surface temperature of the material being coated are critical parameters and as such, are measured and monitored closely. If the core temperature is too high, there can be problems with the substrate splitting and off-gassing. If the surface temperature is not high enough, the powder will not stick to the board.

One of the current issues involves the coating uniformity around the area of where the hook (used for attaching the component to the transfer hoist/conveyor) is attached to the actual component. Knoll is currently looking at different ways to redesign the hook and/or the spray pattern from the top set of spray guns to overcome this issue.

As part of the final qualification of the powder process line, numerous tests and comparisons have been conducted. Mock-ups have been run through the new process and sent out into the field for real-world testing and evaluation. Knoll began to integrate the powder-on-wood products into their manufacturing operations in early 2000.

Gluing Operations

Contact adhesives have traditionally been used by the furniture industry for upholstery operations. Foam is glued to foam and to fabric during the manufacturing of upholstered office chairs. Traditionally, these adhesives have been solvent-borne products with 1,1,1-trichloroethane (also known as methyl chloroform), a HAP and ozone depleting compound, as the primary solvent. In 1994, Knoll switched to hot melt adhesives for the upholstery operations, thereby eliminating methyl chloroform emissions from the process. The hot melt adhesives are 100 percent solids adhesives. Because excess glue residue can be reheated and reused, no adhesive is wasted with the hot melt adhesives. Because there are no emissions from the hot melt adhesives, the facility was able to rework the adhesive application area. Spray booths that were needed when the facility was using solvent-borne adhesives were eliminated. The work area was redesigned so that it has a better work environment that is more comfortable for the operators.

Cleaning Operations

Some of the metal and wood finishing lines at Knoll are hanging lines where parts are hung from metal hooks. These metal hooks collect overspray and they must be cleaned from time-to-time. Previously, Knoll cleaned the hooks using chemical strippers. These strippers not only generated emissions, they also generated liquid waste that had to be treated. In 1994, Knoll purchased a fluidized bed system that uses sand heated to about 1,000°F to clean the hooks. The high temperatures volatilize the dried paint. Eventually, the sand has to be removed and replaced, but the sand that is removed is clean enough that it does not require special or costly disposal. In addition to a significant reduction in emissions and waste, this system has the added benefit of extending the life of the hooks. Knoll estimates that the return on investment for this system was less than one year.

Emissions

The net effect of the clean technology program at Knoll has been significant. Emissions of methyl chloroform have fallen from 54 tons to 0 tons per year due to the implementation of hot melt glues. The VOC content of the solvent-borne wood coatings used previously was 5.9 pounds per gallon. The VOC content of the waterborne wood coatings is only 1.0 pound per gallon. The UV-cured coatings and powder coatings have minimal to no VOC emissions associated with their use. No hazardous materials or cleaning emissions are associated with the powder coating line. According to Knoll personnel, total VOC emissions at the facility have decreased from 200 to 25 tons per year, and will continue to decrease with full implementation of the powder coating line.

Although the emissions reductions have come at considerable cost, approximately \$5 million, the costs have been recovered to date with labor efficiencies, material savings, and increased capacity. Additional savings will be realized in the next few years as the powder-on-wood process is implemented in full.

The clean technology program has and will continue to have a positive environmental effect, reducing or eliminating air emissions, solid waste generation, and water pollution.